

JPL DERATING GUIDELINES

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Change Incorporation Log

Revision	Release Date	Approval	Change Description
Basic	3/91	RK	New Release
A	6/96	RK	General update to deratings
B	2/99	RK	Some derating changed. No controlled records
C			<p>General: Document, tables & graphs reformatted; Scope, intro and derating criteria para.'s revised/clarified.</p> <p><u>Capacitor Section</u>: Section revised to reflect PRF based Mil-Specs; CLR90 & 91 styles added; Notes 3, 6 & 7 added; Surge voltage derating of 6V and 75V caps revised; Note on ESR revised; Capacitor derating examples added.</p> <p><u>Crystals & Crystal Oscillator Section</u>: Section split up in to 3.2.1 & 3.2.2; Crystal derating criteria clarified; Note 5 added.</p> <p><u>Diode Section</u>: Max Tj defined in Note 1; Diode types clarified; Diode derating examples added.</p> <p><u>EMI Filter Section</u>: Scope clarified; Para # & Table # reformatted.</p> <p><u>Hybrid & MCM Section</u>: Section added.</p> <p><u>Magnetic Device Section</u>: Revised to reflect PRF based Mil-Specs; Re-formatted tables; Para. 3.6.1 added; Voltage derating clarified; Type U added; Deleted Mil-T-21038 Type; Para. 3.6.2 added; Type C added; Voltage derating clarified; Notes 1, 2 & 6 added; Transformer derating example added.</p> <p><u>Microcircuits (Digital) Section</u>: Derating criteria for low voltage and plastic parts added; Derating criteria for power dissipation, operating frequency, and endurance added; Notes re-formatted; Notes 3 & 6 added.</p> <p><u>Microcircuits (Linear) Section</u>: Notes reformatted; Notes 3 & 6 added.</p> <p><u>Optoelectronics Section</u>: Scope clarified; Max Tj defined in Note 1; Re-formatted Table and Notes; Laser Diodes added; Optocoupler derating example added.</p> <p><u>Protective Device Section</u>: Section reformatted into fuses and circuit breakers; Para 3.10.1 added; Table 3.10-1 added; Derating curve for solid body style fuses added; Para 3.10.2 added; Fuse derating examples added.</p> <p><u>RF/Microwave Device Section</u>: Section added.</p> <p><u>Relay and Switch Section</u>: Para. 3.12 rewritten; Derated contact current load multiplier clarified; Table L_T added; Notes 2 & 3 added; Relay derating examples added.</p> <p><u>Resistor Section</u>: Para. 3.13 rewritten; Resistor derating factor table added; Notes 1 & 4 added; Revised RCR, RLR, RBR, RWR, RER, RZO resistor derating curves; Resistor derating examples added.</p> <p><u>Thermistor Section</u>: Para. 3.14 rewritten; New derating graph added.</p> <p><u>Transistor Section</u>: Para. 3.15 and Table 3.15-1 clarified; Note 3 revised; Note 4 added; Transistor derating examples added.</p>

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1.0 SCOPE

This document provides guidelines and recommendations for derating of electronic parts used in JPL spaceflight hardware. These guidelines apply primarily to military qualified parts procured and screened to detail military specifications. For applications requiring the use of commercial grade devices, the applicable parts and radiation specialists should be consulted to determine if any additional derating or other mitigation is necessary.

2.0 INTRODUCTION

Derating of a part is the intentional reduction of its electrical, mechanical, and thermal stresses to provide a safety margin between the applied stress and the actual demonstrated limit of the part capabilities. The derating policy established herein is intended to reduce the occurrence of stress related failures and help assure long term reliability.

These guidelines provide derating factors to be applied as a percentage of maximum rated values for critical device parameters such as applied voltages, operating currents, power dissipation, and operating temperatures (ambient, case, or junction). The maximum rated values are typically obtained from the applicable procurement specification, SCD drawing, or manufacturer's data sheets (for commercial devices). Circuit designers and part users should evaluate all part applications and assure that adequate deratings have been achieved.

This document is available at <http://rules>

3.0 DERATING CRITERIA

The derating criteria contained herein apply to worst-case values of electrical and environmental stresses expected during hardware qualification tests. The recommended derating factors are based on the best information currently available and do not preclude further derating. Parts not covered in these guidelines lack sufficient empirical data and failure history. Consult Section 514 component specialists if derating information is needed for a specific part not contained in this document. The manufacturer's maximum operating conditions should never be exceeded.

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

3.1 CAPACITORS

Critical stress parameters for capacitors are applied voltage and operating temperature. Voltage derating for capacitors is accomplished by multiplying the maximum operating voltage by the appropriate derating factor shown in the Table and Graphs below. Maximum derated operating temperatures are shown in the table.

Table 3.1-1 Capacitor Derating Factors

Type	Military Style <u>1/</u>	Specification	Voltage Derating Factor <u>2/</u>	Maximum Operating Temperature <u>3/</u> <u>4/</u>
Ceramic <u>5/</u>	CCR CKS CKR CDR	MIL-PRF-20	0.60	110°C
		MIL-PRF-123	0.60	110°C
		MIL-PRF-39014	0.60	110°C
		MIL-PRF-55681	0.60	110°C
Glass	CYR	MIL-PRF-23269	0.50	110°C
Plastic Film	CRH CHS	MIL-PRF-83421	0.60	85°C
		MIL-PRF-87217	0.60	85°C
Tantalum, Foil	CLR25, CLR27, CLR35, CLR37	MIL-PRF-39006	0.50	70°C
Tantalum, Wet Slug	CLR79, CLR81, CLR90, CLR91	MIL-PRF-39006	0.60	70°C
			0.40 <u>6/</u>	110°C
Tantalum, Solid <u>7/</u>	CSS, CSR	MIL-PRF-39003	0.50	70°C
			0.30 <u>6/</u>	110°C
	CWR	MIL-PRF-55365	0.50	70°C
			0.30 <u>6/</u>	110°C

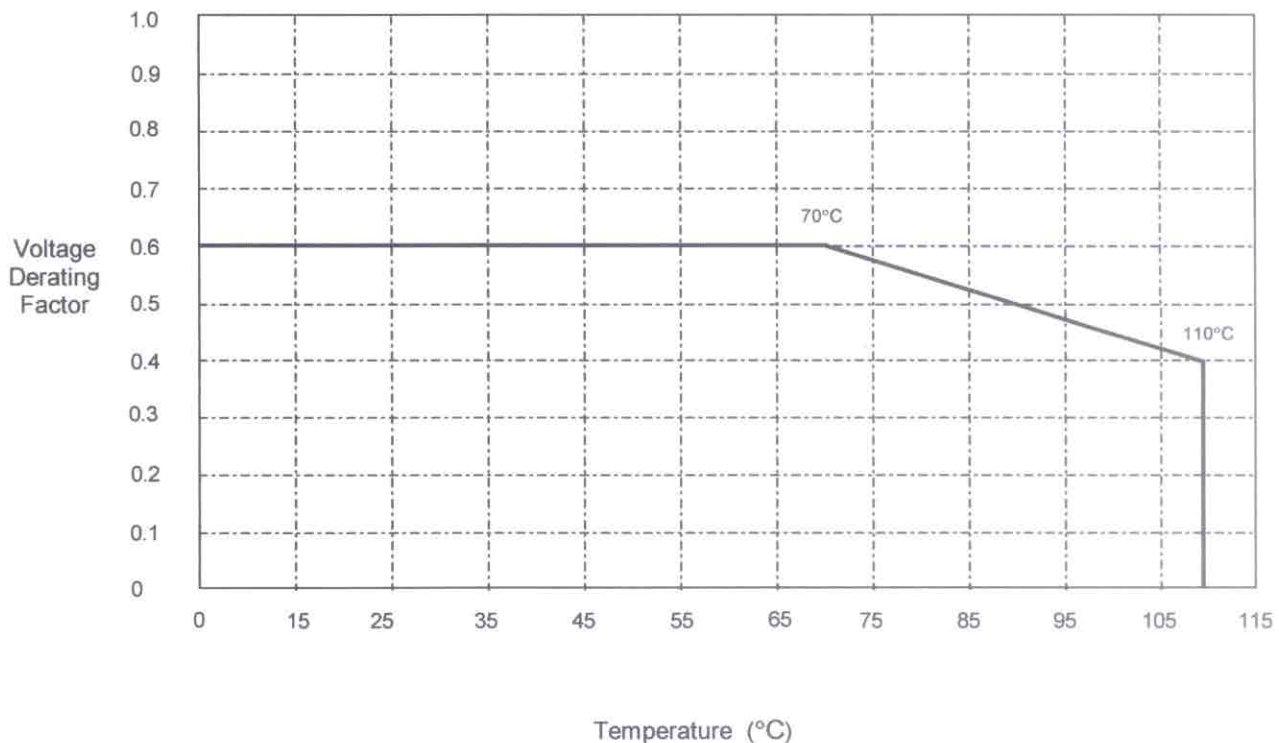
Notes:

- 1/ This derating criteria applies to capacitors processed to military specifications. For applications requiring the use of commercial grade devices consult with the part specialist for applicable derating criteria.

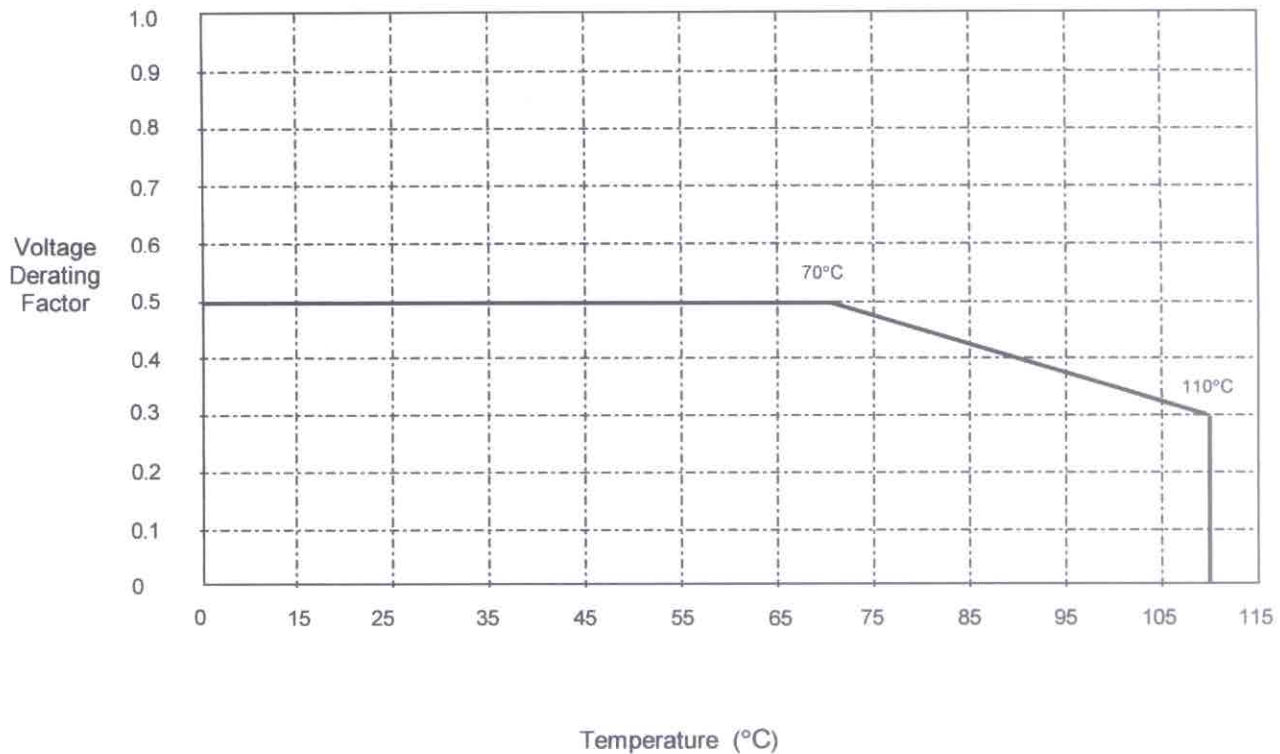
- 2/ The derating factor applies to the sum of peak AC ripple and DC polarizing voltages.
- 3/ Maximum operating temperature is defined as the prevailing temperature in the vicinity of the part or the medium surrounding the part.
- 4/ Maximum operating temperature applies to applications where capacitor is operating at or below maximum derated voltage. For operation above this temperature, consult part specialist for correct derating factor.
- 5/ In low voltage applications (<10 Vdc), multilayer ceramic capacitors with thin dielectrics or other defects may develop low and unstable insulation resistances. In these applications, the capacitor rated voltage must be at least 100 Vdc unless the dielectric thickness of the low voltage capacitor is determined to be equal to or greater than 0.8 mils or the lot has been subjected to humidity and steady state, low voltage testing. Note that capacitors procured to MIL-PRF-123 are screened for this failure mode and are recommended for low voltage applications.
- 6/ Derate voltage linearly from 70°C to 110°C.
- 7/ Solid tantalum capacitors, especially when used in power supply filter applications, are subject to in-rush current failures. In order to protect against this failure mechanism, only surge current tested capacitors should be used and the effective circuit resistance should be 1 ohm minimum. For applications where the capacitors have not been current surge tested, the effective capacitor circuit resistance should be at least 1 ohm/Volt or 3 ohms, whichever is greater. See Paragraph 3.1.2 for additional derating guidelines pertaining to solid tantalum capacitors.

3.1.1 Capacitor Derating Graphs

Tantalum, Wet Slug
CLR79, CLR81, CLR90, CLR91
MIL-PRF-39006



Tantalum, Solid
CSR, CSS, CWR
MIL-PRF-39003
MIL-PRF-55365



3.1.2 Additional Derating notes for Solid Tantalum Capacitors

- a) Surge Currents: Charging and discharging surge currents shall be limited to a maximum of 1 amp per capacitor.
- b) Working Voltage: The applied working voltage (defined as the sum of DC working and AC peak voltages) shall be limited to the values specified in Table 3.1-2.
- c) Surge Voltage: The applied surge voltage shall be limited to the values of Table 3.1-2. Surge voltage is defined as any voltage increase lasting less than 1 millisecond with a duty factor less than 10%.
- d) Transient Voltage: Applied transient voltages shall be limited to the values specified in Table 3.1-2. Transient voltage is defined as any voltage increase lasting less than 100 usec with a duty factor less than 5%.
- e) Reverse Voltage: The applied reverse voltage shall not exceed the values of Table 3.1-2.

f) RMS Current: RMS current shall be limited so that the power generated does not exceed the values specified in Table 3.1-3. Calculate power generated as follows:

$$I_{RMS} \leq (P/ESR)^{0.5}$$

ESR is specified within the detail specification at 25°C, 100KHz. To adjust ESR for fundamental frequency, consult vendor technical data sheets for ESR as a function of frequency or contact part specialist.

Table 3.1-2 Derated Voltage Ratings for Solid Tantalum Capacitors

DC Working Voltage (Non- derated)	-55°C to +85°C				+125°C (Derated linearly from +85°C)			
	Derated Working Voltage (DC + Acpk)	Derated Surge Voltage	Derated Transient Voltage	Derated Reverse Voltage (mV)	Derated Working Voltage (DC + Acpk)	Derated Surge Voltage	Derated Transient Voltage	Derated Reverse Voltage (mV)
6	3.0	3.9	4.8	75	1.8	2.2	2.9	9
10	5.0	6.5	8.0	125	3.0	3.6	4.8	15
15	7.5	9.8	12.0	188	4.5	5.4	7.2	23
20	10.0	13.0	16.0	250	6.0	7.2	9.6	30
35	17.5	22.7	28.0	438	10.5	12.6	16.8	53
50	25.0	32.5	40.0	625	15.0	18.0	24.0	75
75	37.5	48.8	60.0	938	22.5	27.0	36.0	113

Table 3.1-3 Maximum Power Dissipation for Solid Tantalum Capacitors

Standard Case Size (See MIL-PRF-39003/10, Figure 1)	Maximum Derated Power Dissipation (Watts) -55°C to +85°C Ambient
A	0.068
B	0.075
C	0.094
D	0.135

3.1.3 Capacitor Derating Examples

Example 1

A 10pf, 100V CYR glass capacitor is operated at +70°C.

From the derating table: Operating temperature of +70°C is within maximum allowed.

Voltage derating factor of 0.50 results in 50V max allowed operating voltage.

Example 2

A 35V CWR09 solid tantalum capacitor is operated at +85°C ambient temperature.

From the graph: Voltage derating factor of 0.42 at +85°C results in a maximum allowed operating voltage of 14.7V.

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

3.2 CRYSTALS AND CRYSTAL OSCILLATORS

3.2.1 Crystals

Principal stress parameters are drive level, power dissipation, and operating temperature. Drive level shall not exceed 50% of specified maximum rating. Operating temperature shall be maintained within the manufacturer's specified operating temperature range.

3.2.2 Crystal Oscillators

Derating of crystal oscillators is accomplished by multiplying the parameter by the appropriate derating factor specified below.

Table 3.2-1 Crystal Oscillator Derating Factors

Critical Stress Parameters <u>5/</u>	Circuit Implementation		
	With Bipolar Logic	With CMOS 4000 A/B Logic	With Other Logic <u>4/</u>
Absolute Maximum Supply Voltage <u>1/</u>	<u>2/</u>	0.70	0.80
Operating AC/DC Output Current or Fanout	0.80	0.80	0.80
Maximum Junction Temperature	<u>3/</u>	<u>3/</u>	<u>3/</u>

Notes:

- 1/ Under no circumstances shall input voltage, if applicable, be allowed to exceed the supply voltage.
- 2/ Use Manufacturer's recommended maximum operating voltages.
- 3/ Junction temperatures shall not exceed 110°C maximum or 40°C below the manufacturer's absolute maximum rating, whichever is lower.
- 4/ Includes high speed (HCS / HCTS) and advanced (ACS / ACTS / AC / ACT) logic devices.
- 5/ Die or packaged parts used in crystal oscillators from the following part families and manufacturers have sufficiently high voltage ratings to allow for their use in 5V+/-10% supply applications: Intersil HCS/HCTS, Intersil ACS/ACTS, UPMC UT54ACS/ACTS, and National 54AC/ACT. For purposes of parts stress calculations, these part families and manufacturers have 7V absolute supply voltage ratings.

3.3 DIODES

Derating for diodes is accomplished by multiplying the critical stress parameter by the appropriate derating factor and by limiting junction temperatures.

Table 3.3-1 Diode Derating Factors

Diode Type	Critical Stress Parameter	Derating Factor	Maximum Junction Temperature
Small Signal Switching Rectifier Power Schottky Thyristors	Reverse Voltage Forward Current Surge Current	0.75 0.50 0.50	<u>1/</u>
Varactor, Varicap	Power Reverse Voltage Forward Current	0.50 0.75 0.75	<u>1/</u>
Voltage Regulators	Power Zener Current	0.50 $0.75 \times I_{Z(MAX)}$	<u>1/</u>
Voltage Reference	Zener Current	<u>2/</u>	<u>1/</u>
Transient Absorption Zener (TAZ)	Power Dissipation	0.50	<u>1/</u>
FET Current Regulator	Peak Operating Voltage	0.75	<u>1/</u>
RF/Microwave Diodes PIN, multiplier, Schottky, mixer, detector, Gunn, step recovery, tunnel	Power Reverse Voltage Forward Current	0.50 0.75 0.50	<u>1/</u>

Notes:

- 1/ Maximum Junction temperatures for all diode types shall be limited to 125°C or 40°C below the manufacturer's rating, whichever is lower.
- 2/ Operate at manufacturer's specified I_{ZT} to optimize temperature compensation.

3.3.1 Diode Derating Examples

Example 1

A rectifier diode is rated at 1A forward current and 200V reverse voltage. Typically for rectifier diodes, maximum junction to lead thermal resistance ($R_{TH(J-L)}$) at some distance from the diode body (T_L) is given in the detail specification sheet. For this device, $R_{TH(J-L)}$ is specified at 38°C/W @ $T_L = 0.375"$. During operation, diode lead temperature for this application is determined to be 80°C at $T_L = 0.375"$.

Applying derating criteria: $I_F \text{ max} = 0.5 \times 1\text{A} = 0.5\text{A}$
 $V_R \text{ max} = 0.75 \times 200\text{V} = 150\text{V}$

Note that typical forward voltage of 0.7V and maximum applied forward current of 0.5A results in power dissipation of 350mW.

Calculating junction temperature: $T_J = T_L + R_{TH(J-L)} \times P_D$
 $= 80^{\circ}\text{C} + (38^{\circ}\text{C/W} \times .35\text{W})$
 $= 80^{\circ}\text{C} + 13^{\circ} = 93^{\circ}\text{C}$

This application is in conformance with the derating criteria.

Example 2

A 6.8V zener regulator diode is rated at 1.5W and 210mA maximum zener current (I_{ZM}). Operation is at a Zener current (I_{ZT}) of 50mA and case temperature (T_C) of 100°C . Junction to ambient thermal resistance ($R_{TH(J-C)}$) is specified at 83°C/W .

Applying derating criteria: $I_{ZM} \text{ max} = 0.75 \times 210\text{mA} = 157\text{mA}$
 $P_D \text{ max} = 0.5 \times 1.5\text{W} = 750\text{mW}$

Calculating power dissipation: $P_D = 6.8\text{V} \times 50\text{mA} = 340\text{mW}$

Calculating junction temperature: $T_J = T_C + R_{TH(J-C)} \times P_D$
 $= 100^{\circ}\text{C} + (83^{\circ}\text{C/W} \times 0.34\text{W})$
 $= 100^{\circ}\text{C} + 28^{\circ} = 128^{\circ}\text{C}$

T_J exceeds maximum allowed. Either I_{ZT} or operating temperature must be reduced to conform to derating requirements.

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

3.4 EMI FILTERS

Lumped element or potted EMI Filters are derated by multiplying the critical stress parameter by the appropriate derating factor. Operating temperature shall not exceed the specified maximum value. See section 3.5 herein for hybrid based filter deratings.

Table 3.4-1 EMI Filter Derating Factors

Filter Type	Critical Stress Parameter	Derating Factor	Maximum Operating Temperature
ALL	Rated Current	0.75	<u>1/</u>
	Rated Voltage	0.50	

1/ Maximum operating temperature shall be 85°C or 30°C below the manufacturer's maximum rating, whichever is lower. The maximum operating temperature is defined as the case temperature of the device.

3.5 HYBRIDS AND MULTI-CHIP MODULES (MCMs)

Unlike traditionally packaged electronic components, the Hybrid or MCM thermal environment for each application must be considered separately on its own merit. Failure rates being an exponential function of temperature for all electronic components, it is essential to make an accurate thermal analysis to predict reliability of each component constituting the Hybrid or MCM. Package density/mounting determines the thermal rise particular to the individual package design.

Derating of Hybrid and MCM devices are accomplished by considering the most reliability-limiting element contained within the packaged device. All internal passive and active devices need to be considered separately by referring to the individual part sections within this document and obtaining the parts and radiation specialists' concurrences.

3.6 MAGNETIC DEVICES (TRANSFORMERS / INDUCTORS / COILS)

Transformers, inductors and coils are derated by reducing operating temperature based on the insulation class used and by reducing maximum rated operating voltage and current.

3.6.1 Transformers

Table 3.6-1 Transformer Derating Factors

Insulating Class <u>1/ 3/</u>	Maximum Operating Temperature <u>4/</u>	Derated Operating Temperature <u>5/</u>	Operating Parameters	
MIL-PRF-27	Rated	Derated	Voltage	Current
Q	85°C	65°C	50% of maximum rated DWV	50% of maximum rated
R	105°C	85°C		
S	130°C	105°C		
V	155°C	130°C		
T	170°C	155°C		
U	>170°C	<u>6/</u>		

3.6.2 Inductors / Coils

Table 3.6-2 Inductor/Coil Derating Factors

Insulating Class <u>2/ 3/</u>		Maximum Operating Temperature <u>4/</u>	Derated Operating Temperature <u>5/</u>	Operating Parameters	
MIL-PRF-39010	MIL-PRF-15305	Rated	Derated	Voltage	Current
—	O	85°C	65°C	50% of maximum rated DWV	50% of maximum rated
A	A	105°C	85°C		
B	B	125°C	105°C		
—	C	>125°C	<u>6/</u>		
F	—	150°C	130°C		

Notes:

- 1/ For transformers procured to MIL-PRF-21038, derate to 80% of specified maximum rated operating temperature. Derate voltage and current per Table 3.6-1 above.

- 2/ For RF coils procured to MIL-PRF-83446, derate to 80% of specified maximum operating temperature. Derate voltage and current per Table 3.6-2 above.
- 3/ Custom made devices shall be evaluated on a materials basis to establish maximum rated operating temperature. This temperature shall then be derated by a factor of 0.75.
- 4/ Maximum operating temperature is defined as maximum case temperature plus temperature rise of the winding plus 10°C (allowance for hot spot).

Temperature rise is calculated as follows (see MIL-PRF-27, Para 4.8.12):

$$\Delta T = (R - r) / r (t + 234.5^{\circ}\text{C}) - (T - t)$$

Where: ΔT = Temperature rise above case temperature in °C.

R = winding resistance at elevated temperature ($T + \Delta T$).

r = winding resistance at case temperature (t).

t = initial case temperature in °C.

T = maximum case temperature in °C at time of power shutdown.

Note: T should not differ from t by more than 5°C.

- 5/ Maximum rated operating temperatures specified in the table are based on a life expectancy of 10,000 hours. Derated operating temperatures are selected to extend life expectancy to 50,000 hours.
- 6/ Derate to 80% of specified maximum rated operating temperature.

3.6.3 Transformer derating example

A 100Vac / 24Vac step down transformer is to be designed and fabricated to MIL-PRF-27 using Class Q insulation. Operating temperature will be +40°C. A dielectric withstanding voltage (DWV) rating of 100Vac is required for the application. Winding resistance (r) is 2.5Ω at $T_C = 25^{\circ}\text{C}$ and increases to $R = 2.95\Omega$ at $T_C = 30^{\circ}\text{C}$.

$$\begin{aligned}\text{Calculating temperature rise: } \Delta T &= (R - r) / r (t + 234.5^{\circ}\text{C}) - (T - t) \\ &= 2.95 - 2.5 / 2.5 (25^{\circ}\text{C} + 234.5^{\circ}\text{C}) - (30^{\circ}\text{C} - 25^{\circ}\text{C}) \\ &= (0.18) (259.5^{\circ}\text{C}) - 5^{\circ}\text{C} = 41.7^{\circ}\text{C}\end{aligned}$$

$$\text{Maximum operating temperature} = T_C + \Delta T + 10^{\circ}\text{C} = 40^{\circ}\text{C} + 41.7^{\circ}\text{C} + 10^{\circ}\text{C} = 91.7^{\circ}\text{C}$$

Since maximum derated operating temperature for Class Q insulation is only 65°C, Class S (105°C) or higher rated insulation must be used. Insulation DWV rating should be 220Vac minimum.

3.7 MICROCIRCUITS (DIGITAL)

Derating of Silicon digital microcircuits is accomplished by multiplying the parameter by the appropriate derating factor specified below.

Table 3.7-1 Digital Microcircuit Derating Factors

Critical Stress Parameters	Bipolar	CMOS				LSI/VLSI		ASIC
	Logic, Line Drivers/ Receivers	4000 A/B Logic	LVDS	Other Logic ^{4/}	Line Drivers/ Receivers	Bipolar	CMOS	Digital and Mixed Signal
Absolute Maximum Supply Voltage ^{1/} (5V+/-10% & above)	<u>2/</u>	0.70	0.80 ^{3/}	0.80 ^{3/}	0.80 ^{3/}	<u>2/</u>	<u>2/</u>	<u>2/</u>
Absolute Maximum Supply Voltage (Low voltage, 3.3V +/-10% & lower) ^{1/}	N/A	N/A	<u>2/</u>	0.80	0.80	<u>2/</u>	<u>2/</u>	<u>2/</u>
Input Voltage	Input voltage shall not be allowed to exceed the supply voltage unless specifically approved by the parts specialist.							
Open Collector/Drain DC Output Voltage	0.80	0.80	N/A	0.80	0.80	0.80	0.80	0.80
Operating AC/DC Output Current or Fanout	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Power Dissipation	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Maximum Junction Temperature	^{5/} Hermetic ^{6/} Plastic							
Max. Operating Frequency	0.80							
Read/Write cycles for EEPROM/FLASH EEPROM	N/A						0.5 of manufacturer's rated endurance	

Notes:

- ^{1/} For those technologies where no supply voltage derating is specified, in no case shall the device maximum operating supply voltage be exceeded.
- ^{2/} Use Manufacturer's recommended operating voltages.
- ^{3/} The following part families and manufacturers have sufficiently high voltage ratings to allow for their use in 5V+/-10% supply applications: Intersil HCS/HCTS, Intersil ACS/ACTS, Intersil 26C31/32, UPMC UT54ACS/ACTS, UPMC LVDS (Low Voltage Differential Signaling), and National 54AC/ACT. For purposes of parts stress calculations, these part families and manufacturers have 7V absolute supply voltage ratings.
- ^{4/} Includes high speed (HCS/HCTS) and advanced (ACS/ACTS/AC/ACT) logic devices.
- ^{5/} Junction temperatures shall not exceed 110°C maximum or 40°C below the manufacturer's absolute maximum rating, whichever is lower. If the absolute maximum junction temperature is not specified within the manufacturer's data sheet, derate from the maximum specified storage temperature.
- ^{6/} Operating T_j for plastic commercial and industrial grade parts shall be at least 10°C below the manufacturer's maximum operating temperature rating or 110°C, whichever is lower.

3.8 MICROCIRCUITS (LINEAR)

Derating of Silicon linear microcircuits is accomplished by multiplying the parameter by the appropriate derating factor specified below.

Table 3.8-1 Linear Microcircuit Derating Factors

Critical Stress Parameters	Comparators	Sense Amplifiers	Operational/Differential Amplifiers	Other Amplifiers <u>1/</u>	Voltage Regulators	Analog Switches	A/D and D/A Converters
Absolute Max. Supply Voltage <u>2/</u>	0.80	0.80	0.80	0.80	<u>3/</u>	0.80	0.80
Diff. Input Voltage <u>4/</u>	0.70	0.70	0.70	0.70	N/A	N/A	N/A
Single-Ended DC Input Voltage <u>4/</u>	N/A	N/A	N/A	N/A	0.80	0.80	0.80
Power Dissipation	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Open Collector/Drain DC O/P Voltage	0.75	0.75	N/A	N/A	N/A	N/A	N/A
Operating AC or DC O/P Current	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Max. Short Ckt O/P Current	0.80	0.80	0.80	0.80	0.80	N/A	N/A
Max. Junction Temperature	<u>5/</u> Hermetic <u>6/</u> Plastic						

Notes:

- 1/ Other amplifiers include Current, Voltage Follower, Instrumentation, Video, and Sample and Hold.
- 2/ For devices with maximum ratings greater than 10V, derate by at least 2V below the absolute maximum voltage rating of each rail.
- 3/ Dropout voltage should be derated to 0.80
- 4/ Under no circumstances shall input voltage be allowed to exceed the supply voltage.
- 5/ Junction temperatures shall not exceed 110°C maximum or 40°C below the manufacturer's absolute maximum rating, whichever is lower. If the absolute maximum junction temperature is not specified within the manufacturer's data sheet, derate from the maximum specified storage temperature.
- 6/ Operating Tj for plastic commercial and industrial grade parts shall be at least 10°C below the manufacturer's maximum operating temperature rating or 110°C, whichever is lower.

3.9 OPTOELECTRONIC DEVICES

Derating is accomplished by multiplying the appropriate stress parameter by its derating factor and by limiting junction temperatures.

Table 3.9-1 Optoelectronics Derating Factors

Device Type	Critical Stress Parameter	Derating Factor	Maximum Junction Temperature
Light Emitting Diodes, Photo Diodes, & Photo Transistors	Power Current Voltage	.50 .75 .75	<u>1/</u>
Laser Diodes	Power	<u>2/</u>	<u>1/</u>
Optocouplers <u>3/</u> <u>4/</u>	Power Current Voltage	.50 .75 .75	<u>1/</u>

Notes:

- 1/ Maximum junction temperatures for optoelectronic devices shall be limited to 95°C or to 30°C below the manufacturer's maximum rating, whichever is lower.
- 2/ Consult the respective parts and radiation specialists for deratings due to aging and radiation.
- 3/ For optimum coupling efficiency, use manufacturers recommended operating conditions.
- 4/ Recent experiences have indicated that optocouplers, in general, are unusually sensitive to Single-Event transients. Consult with the appropriate Parts Specialist and/or the JPL Radiation Effects and Testing group prior to selecting optocouplers for flight applications.

3.9.1 Optocoupler Derating Example

An optocoupler has the following maximum ratings:

Input Current (I_F) = 40mA
Collector Current (I_C) = 50mA
Collector-Emitter Voltage (V_{CEO}) = 40V
Collector-Base Voltage (V_{CBO}) = 45V
Emitter-Base Voltage (V_{EBO}) = 40V
Power Dissipation (P_D) = 1W @ $T_C = 25^\circ\text{C}$ (derate at 10mW/ $^\circ\text{C}$)
Junction Temperature (T_J) = 125 $^\circ\text{C}$
Junction to Ambient thermal resistance ($R_{TH(J-C)}$) = 100 $^\circ\text{C/W}$

Applying derating criteria:

$I_F = 0.75 \times 40\text{mA} = 30\text{mA}$
 $I_C = 0.75 \times 50\text{mA} = 37.5\text{mA}$
 $V_{CEO} = 0.75 \times 40\text{V} = 30\text{V}$
 $V_{CBO} = 0.75 \times 45\text{V} = 33.75\text{V}$
 $V_{EBO} = 0.75 \times 7\text{V} = 5.25\text{V}$
 $T_J = 95^\circ\text{C}$ (maximum allowed)
 $P_D = 0.5 \times 1\text{W} = 500\text{mW}$ @ $T_C = 25^\circ\text{C}$ (150mW @ $T_C = 60^\circ\text{C}$)

Calculating P_D based on operation at $T_J = 95^\circ\text{C}$ and worst case $T_C = 60^\circ\text{C}$:

$$P_D = T_J - T_C / R_{TH(J-C)} = 95^\circ\text{C} - 60^\circ\text{C} / 100^\circ\text{C/W} = 35 / 100 = 350\text{mW}$$

Note that when P_D is calculated based on maximum allowed T_J , the calculation of $0.5 \times \text{max } P_D$ is not applicable.

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

3.10 PROTECTIVE DEVICES (FUSES/CIRCUIT BREAKERS)

Derating of protective devices is accomplished by multiplying the current rating by the appropriate derating factors specified below.

3.10.1 Fuses

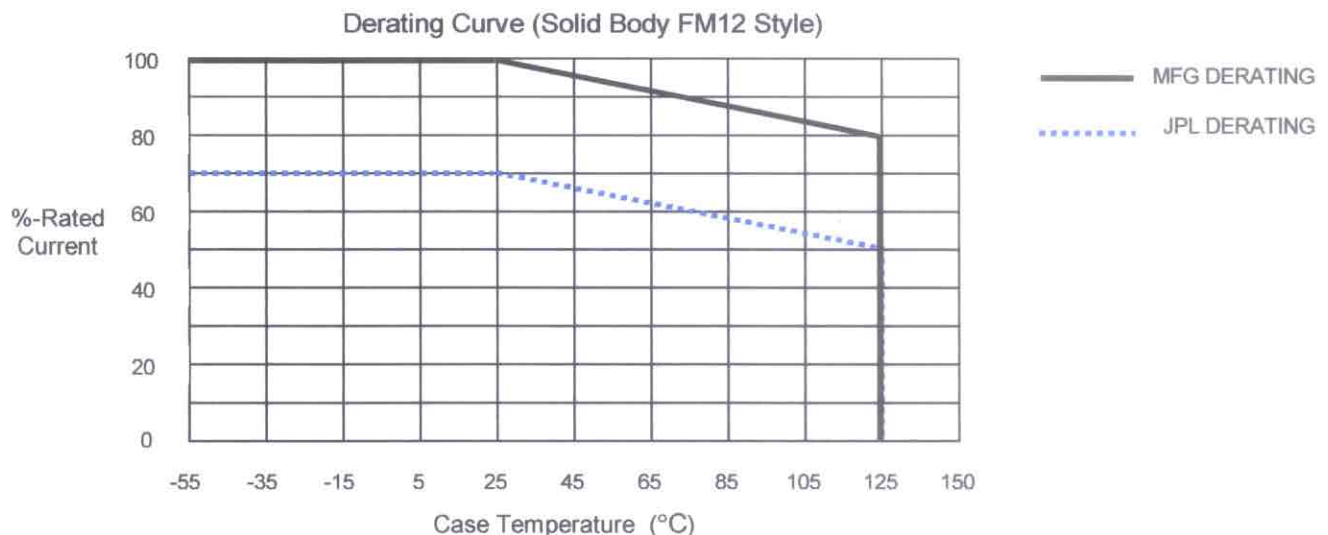
Fuses are derated by applying the appropriate factors as shown in the derating table for cavity style fuses and the derating curve for solid body styles. Fuse derating factors are based on data from fuses mounted on printed circuit boards, with conformal coating and operating in a vacuum environment. For other types of mounting, consult the part specialist for recommendations.

Derating of cavity style fuses allows for the potential loss of air pressure within the cavity over time. This reduces the filament cooling mechanism resulting in lower blow current ratings.

Solid body fuses are not affected by vacuum. Derating is dependent on case temperature only and independent of vacuum conditions.

Table 3.10-1 Fuse Derating Factors (Cavity FM08 Style)

Fuse Value (Amps @25°C)	Derating Factor (Current)	Temperature Derating	Voltage Derating
1/8	0.25	Apply additional derating of 0.5%/°C for fuse body temperatures above 25°C	To prevent the occurrence of open circuit enduring arcs, open circuit voltage should not exceed 40% of the fuse voltage rating.
1/4	0.30		
3/8	0.35		
1/2	0.40		
3/4	0.40		
1.0	0.45		
1.5	0.45		
2 - 15	0.50		



3.10.2 Circuit Breakers

Derate circuit breakers by multiplying the current rating by the appropriate derating factor specified below.

Table 3.10-2 Circuit breaker Derating Factors

Contact Application	Contact Current Derating Factor	Maximum Operating Temperature
Resistive	0.75	20°C below maximum rated temperature
Capacitive	0.75 ^{1/}	
Inductive	0.40	
Motor	0.20	
Filament	0.10	

Notes:

^{1/} Use series resistance to assure those circuits do not exceed the derated value.

3.10.3 Fuse Derating Examples

Example 1

A cavity style fuse is to be operated in a space application at 80°C. Maximum current to be fused is 0.9A. Buss voltage is 28V.

Temperature Derating: $0.5\%/^{\circ}\text{C} \times 55^{\circ}\text{C} = 27.5\%$

Fuse value with temperature derating: $0.9\text{A} \div (1 - 0.275) = 0.9\text{A} \div 0.725 = 1.24\text{A}$

Derate 50% for vacuum environment: $1.24\text{A} \times 1/0.5 = 2.48\text{A}$

For calculations resulting in fractional values, use the next highest fuse value.

A fuse rated at 2.5A or greater and 70V or greater is required for this application.

Example 2

A solid body fuse is to be operated in a space application at 75°C. Maximum current to be fused is 0.5A.

Derate by 60% to $0.5\text{A} \times 1/0.6 = 0.83\text{A}$

Application requires a 1A fuse.

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

3.11 RF/MICROWAVE PARTS

RF/Microwave parts shall be derated by multiplying the critical stress parameter by the appropriate derating factor, unless otherwise specified. Some parts contain internal active or passive elements. Derating guidelines for internal elements should be referred to within this document where applicable.

Table 3.11-1 RF/Microwave Derating Factors

Type	Reference Specification	Critical Stress Parameter	Derating Factor <u>6/</u>
Adapters: Coaxial Coax to Waveguide	MIL-PRF-55339 MIL-DTL-22641		<u>3/</u>
Amplifiers	MIL-DTL-28875	<u>1/</u>	MIL-STD-1547, <u>2/</u> , <u>3/</u>
Attenuators: Fixed Variable	MIL-DTL-3933 MIL-A-24215	<u>1/</u>	<u>3/</u> MIL-STD-1547, <u>2/</u> , <u>3/</u>
Coils: (non air core) Fixed & Variable Fixed Fixed & Variable	MIL-PRF-15305 MIL-PRF-39010 MIL-PRF-83446	See 3.6.2	See 3.6.2
Ferrites: Circulators, Isolators	MIL-DTL-28791	See 3.13	See 3.13, <u>3/</u> , <u>4/</u>
Couplers	MIL-DTL-15370	<u>1/</u>	<u>3/</u>
Delay Lines	MIL-PRF-83532	<u>1/</u>	See 3.6
Diodes	MIL-PRF-19500	See 3.3	See 3.3
Dummy Loads/Terminations	MIL-DTL-39030		<u>3/</u>
Filters, Diplexers	MIL-D-28963, MIL-PRF-15733, MIL-F-18327	<u>1/</u>	<u>3/</u>
Flange, Coaxial	MIL-DTL-24044		<u>3/</u>
Integrated Microwave Assembly (IMA)	MIL-PRF-38534	<u>1/</u>	MIL-STD-1547, <u>2/</u> , <u>3/</u>
Mixers, Multiplexers	MIL-DTL-28837	See 3.3, <u>1/</u>	See 3.3, <u>2/</u> , <u>3/</u>
Monolithic Microwave Integrated Circuits (MMIC)	MIL-PRF-38535	See 3.8	See 3.8 notes 5 & 6, <u>3/</u>
Oscillators (non Crystal or Gunn) Frequency Standard	MIL-PRF-38534 MIL-F-21584 (history)	<u>1/</u>	MIL-STD-1547, <u>2/</u> , <u>3/</u>
Power Dividers	MIL-DTL-23971	<u>1/</u>	<u>3/</u>
Switches: <u>5/</u> Electro-mechanical Solid State	MIL-DTL-3928 MIL-DTL-83739	See 3.12 <u>1/</u>	See 3.12, <u>3/</u> See 3.3 & MIL-STD-1547, <u>2/</u> , <u>3/</u>
Transformers	MIL-T-55631	See 3.6.1	See 3.6.1, <u>3/</u>

Table 3.11-1 RF/Microwave Derating Factors (Cont.)

Type	Reference Specification	Critical Stress Parameter	Derating Factor 6/
Transistors	MIL-PRF-19500	See 3.15, 1/	See 3.15
Transmission Line Assemblies Coaxial	MIL-L-28796 MIL-L-2890		3/
Tubes	MIL-PRF-1		3/
Waveguide: Rigid, Rectangular Single & Double Ridge Elliptical Flex Flange Dummy Load Assembly, Rigid Twists & Bends Switch Assembly Gaskets	MIL-DTL-85 MIL-W-23351 MIL-W-28839 MIL-DTL-287 MIL-DTL-3922, MIL-DTL-39000 MIL-D-3954 MIL-DTL-3970, MIL-HDBK-660 MIL-DTL-55041 MIL-DTL-3970 MIL-DTL-24211		3/

Notes:

1/ For "hybrid" (MIC, IMA) and "lumped element" type RF devices, derating should apply to the constituent individual element parts and a table shall be produced detailing the derating of each item. Criteria shall be in accordance with the respective section of this document.

2/ Highest calculated junction or channel temperature for each active device in the assembly shall be maintained below +125C, or 40C below the device's maximum temperature rating, whichever is lower. Capacitors shall meet the criteria specified in Table 3.1-1. Monolithic microcircuit semiconductor die shall meet the criteria specified in Table 3.8-1 notes 5 and 6. Contact the parts engineering specialist to determine if epoxy, potting and other materials used inside the component require a maximum mission operating temperature be maintained below +125C.

3/ RF Input Power shall be derated from the manufacturers specified maximum rated input power by 1.5dB (in dBm) or a multiplication factor of .70 (in Watts).

4/ Temperature effects from RF losses in the ferrite can lead to self-heating. Reference section 3.13 for temperature and power derating considerations since ferrite junction isolators contain either chip or non-inductive rod resistors. Refer to the appropriate parts specialist for additional recommendations on specific part types and manufacturers.

5/ RF switches are subject to burnout in RF hot switching applications of moderate to high power levels. Hot switching is allowed only in low RF power applications (< +20dBm or 100mW) with the parts specialist's concurrence.

6/ Ionization, multipacting, and corona discharge considerations shall be addressed by the COG-E on all high voltage and RF components where the field strengths may be sufficiently high to support a breakdown. If the analysis does not demonstrate an adequate design margin, as specified in the level 3, 4, or 5 project requirements, then a component level test shall be performed at an appropriate level and in a relevant simulated environment.

- Components and equipment are typically analyzed for breakdown in their relevant operating environment(s). Usually, a component, as determined by analysis not to have 10dB of breakdown margin, should be tested to ensure adequate margin.
- Passive RF components requiring testing are typically tested to a value of 6dB above the maximum operating power in a relevant environment.
- High voltage issues with static and low frequency dynamic fields are complex and need special attention. Design precautions should be exercised at all levels above 250VDC.

3.12 RELAYS AND SWITCHES

Principal stress parameters for relays and switches are continuous contact current and temperature. Derating is accomplished by reducing maximum contact currents based on operating temperature, load conditions and cycle rates.

Derated contact current (I_{DM}) is determined by multiplying contact current maximum rating (I_{RM}) and the product of T, R, L_A and L_T taken from the following tables.

$$I_{DM} = I_{RM} \times T \times R \times L_A \times L_T$$

Where: T = operating temperature
R = cycle rate
 L_A = load application
 L_T = load type

Table 3.12-1 Table T (Operating Temperature)

Temperature Range	-65°C to -21°C	-20°C to +39°C	+40°C to +84°C	+85°C to +125°C
Derating Factor	0.85	0.90	0.85	0.70

Table 3.12-2 Table R (Cycle Rate)

Cycle Rate per hour	<1.0	1.0 to 10	>10
Derating Factor	0.85	0.90	.85

Table 3.12-3 Table L_A (Load Application) Note 1/

Load Application	A (to 0.5 sec.)	B (to 5 min.)	C (other)
Derating Factor	1.0	1.5	0.8

Table 3.12-4 Table L_T (Load Type)

Load Type	Resistive	Capacitive	Inductive	Motor	Filament
Derating Factor	1.0	1.0	0.5	0.2	0.1

Notes:

- 1/ Load A - Make Break and/or carry loads with on-time duration of 0 to 500 milliseconds and off-time \geq on time.
 Load B - Carry only loads (contacts are closed before there is current flowing through the contacts and current is not interrupted by the contacts). Relay/switch does not make or break the load. Maximum on-time is 5 minutes; off-time is \geq on-time.
 Load C - Make, break and/or carry. Those loads that do not fall into the category of loads A or B such as long term continuous use.
- 2/ Do not derate relay coil voltage or current. Operating at less than nominal coil voltage can result in switching failures and reduced relay reliability.
- 3/ For transient current surges, during switching, that exceed the maximum derated contact current, use the following derating criteria:

$$\begin{aligned} \text{For } t \leq 10\mu\text{s:} \quad & I_{SM} \leq 4 \times I_{DM} \\ \text{For } t > 10\mu\text{s:} \quad & (I_{SM})^2 \times t \leq 16 \times (I_{DM})^2 \times 10^{-5} \text{ (A}^2\text{s)} \end{aligned}$$

Where: t = Period of time during which transient current exceeds I_{DM}
 I_{SM} = Maximum surge current allowed
 I_{DM} = Maximum derated contact current

3.12.1 Relay Derating Examples

Example 1

A relay with a contact current rating of 1A is operated at 70°C. Relay is cycled at a rate of 5 cycles per hour into a purely resistive load. Load application is make, break and carry for on and off times of 400 ms duration.

Selecting the appropriate factors from the tables:

$$I_{DM} = I_{RM} \times T \times R \times L_A \times L_T = 1A \times 0.765 = 0.765A$$

Example 2

The same 1A relay is subjected to periodic current surges of 4A peak for 12 μ s duration.

Using the formula for $t > 10\mu\text{s}$:

$$16 \times 12\mu\text{s} = 192 \times 10^{-6} \text{ A}^2\text{s} \quad ; \quad 16 \times .585 \times 10^{-5} = 93.6 \times 10^{-6} \text{ A}^2\text{s}$$

Surge current value exceeds maximum allowed. Peak amplitude and/or duration of surges must be reduced or a relay with higher rated contact current must be substituted.

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

3.13 RESISTORS

Resistors are derated by multiplying the resistor's maximum rated power and voltage by the appropriate power factor. This factor is also a function of the resistor maximum operating temperature as shown in the following table and graphs.

The resistor derating graphs profiled in Para. 3.13.1 are tabulated in Table 3.13-1 below.

Table 3.13-1 Resistor Derating Factors 1/

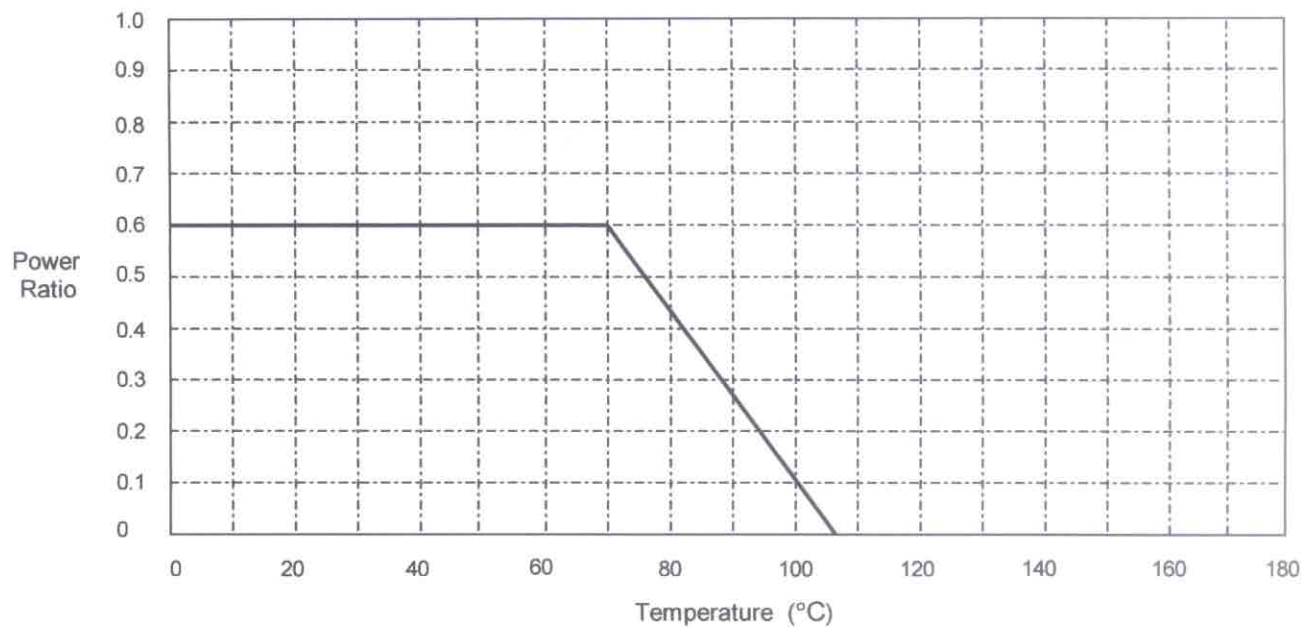
Resistor Type	Description	Power Derating Factor	Derating Temperatures (°C)		Voltage Derating Factor <u>2/ 3/</u>
			T1	T2	
RCR	Fixed Carbon (MIL-PRF-39008)	0.6	70	106	0.8
RNC, RNR, RNN	Fixed Metal Film (MIL-PRF-55182)	0.6	125	155	0.8
RLR	Fixed Film, Insulated (MIL-PRF-39017)	0.6	70	118	0.8
RBR	Fixed Wire Wound, Accurate (MIL-PRF-39005)	0.6	125	137	0.8
RTR	Variable, Wire Wound (MIL-PRF-39015)	0.6	85	124	0.8
RWR	Fixed Wire Wound, Power (MIL-PRF-39007)	0.6	25	160	0.8
RER	Fixed Wire Wound, Power, Chassis Mount (MIL-PRF-39009)	0.6	25	160	0.8
RZO	Fixed Film, Networks (MIL-PRF-83401)	0.6	70	103	0.8
RM	Fixed Film, Chip (MIL-PRF-55342)	0.6	70	118	0.8

Notes:

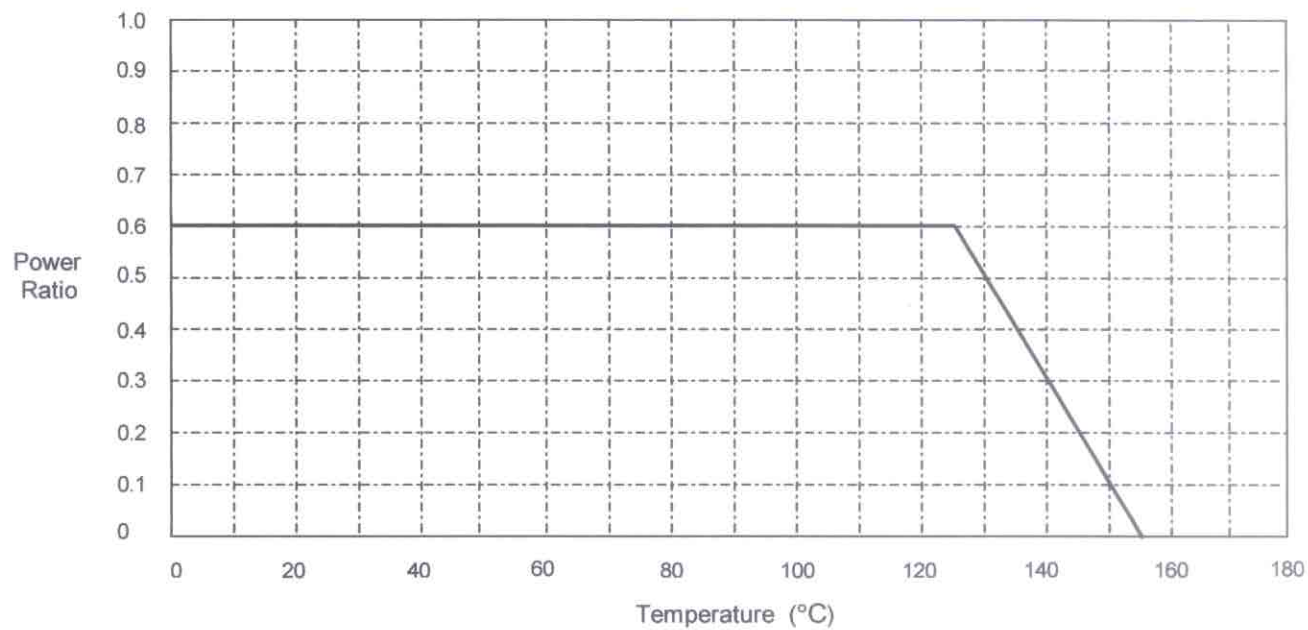
- 1/ For operating temperatures $\leq T1$, multiply nominal power rating by the appropriate power factor. For operation above T1, derate linearly from the T1 power level to the zero power level at T2.
- 2/ Maximum applied voltage shall not exceed 80% of maximum rated voltage. Where no maximum voltage is specified, applied voltage shall be limited to $0.8\sqrt{PR}$ where P is the maximum rated power in Watts and R is nominal resistance in ohms.
- 3/ This voltage derating applies to DC and regular waveform AC applications. For pulse and other irregular waveforms consult the applicable part specialist.

3.13.1 Resistor Derating Graphs

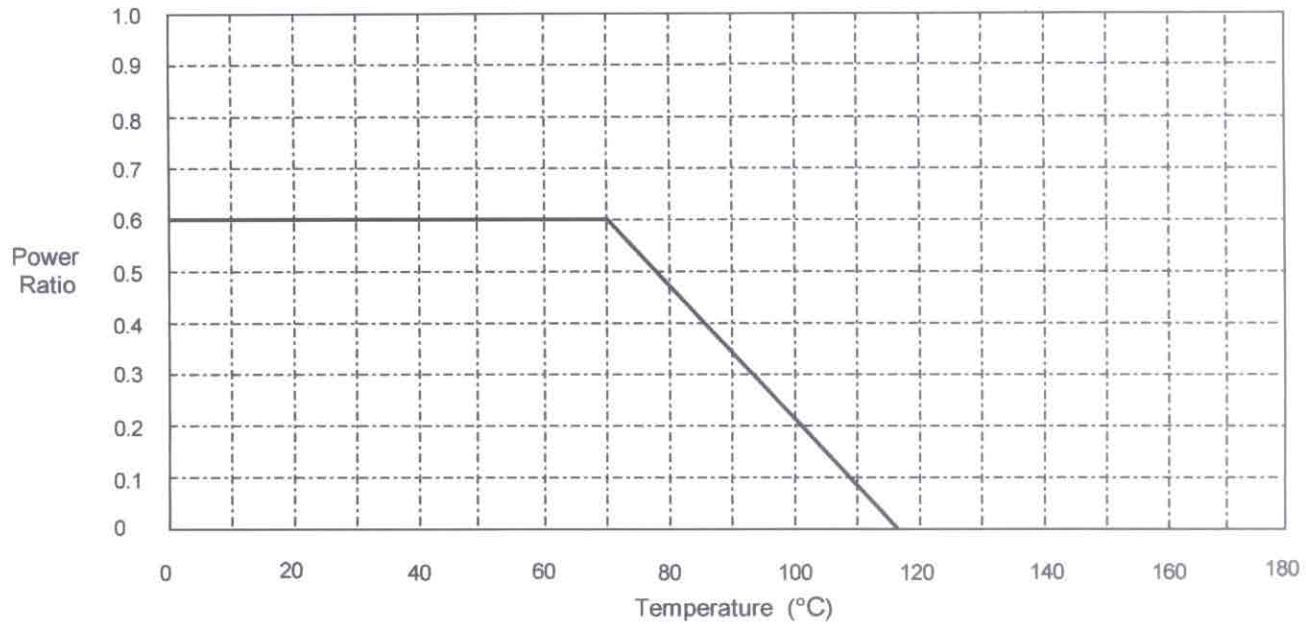
Fixed Carbon
Type RCR
MIL-PRF-39008



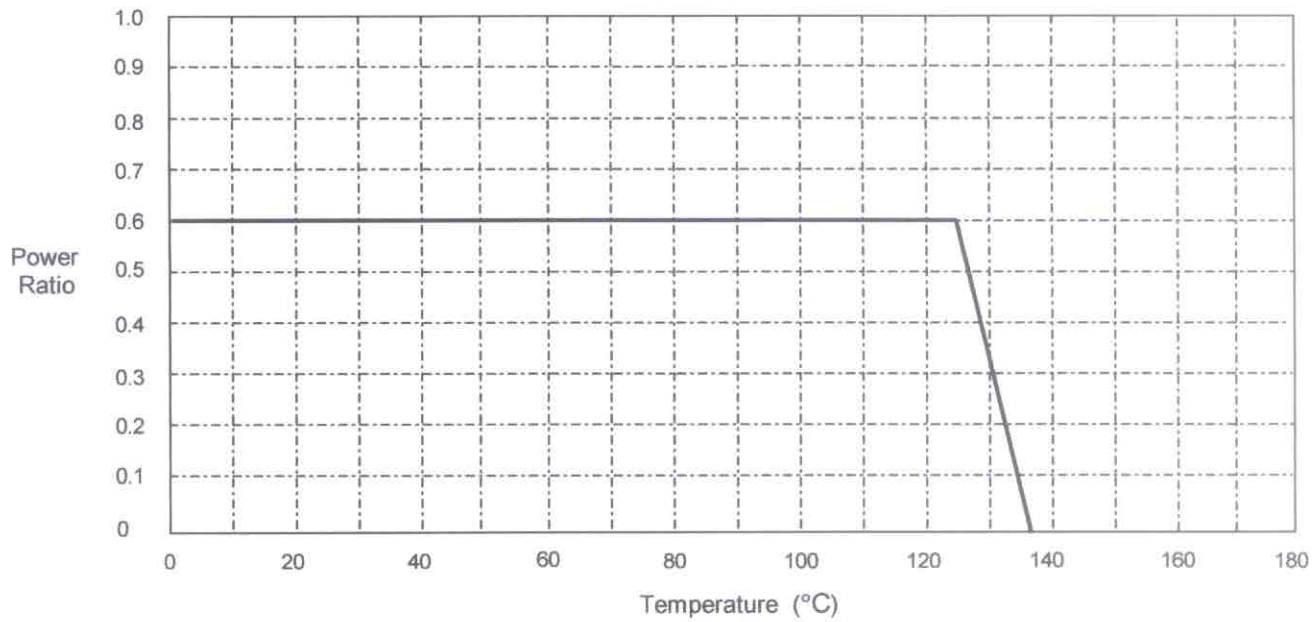
Fixed Metal Film
Type RNC, RNR, RNN
MIL-PRF-55182



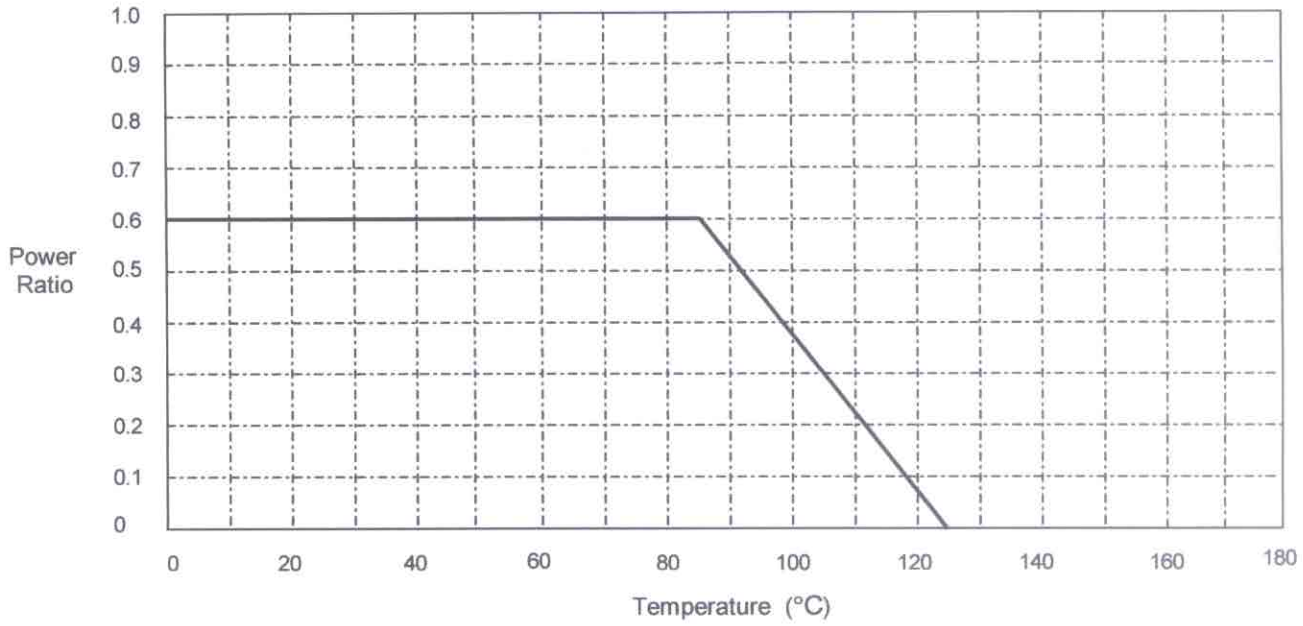
Fixed Film, Insulated
Type RLR
MIL-PRF-39017



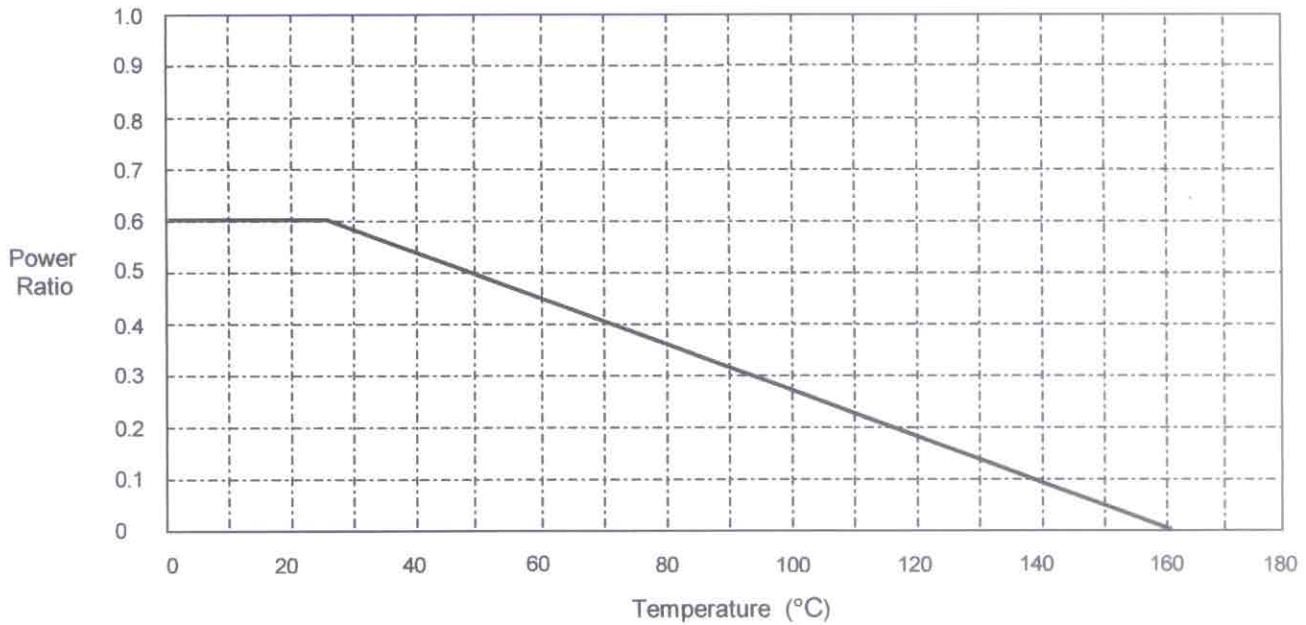
Fixed Wirewound, Accurate
Type RBR
MIL-PRF-39005



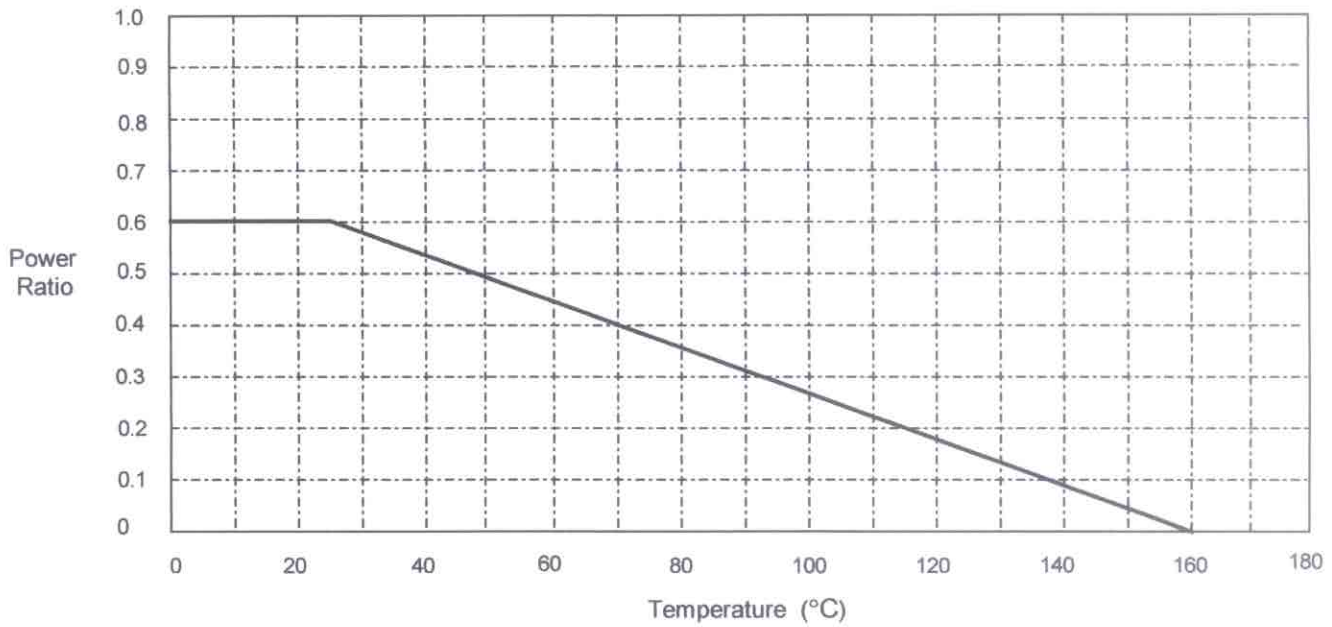
Variable Wirewound
Type RTR
MIL-PRF-39015



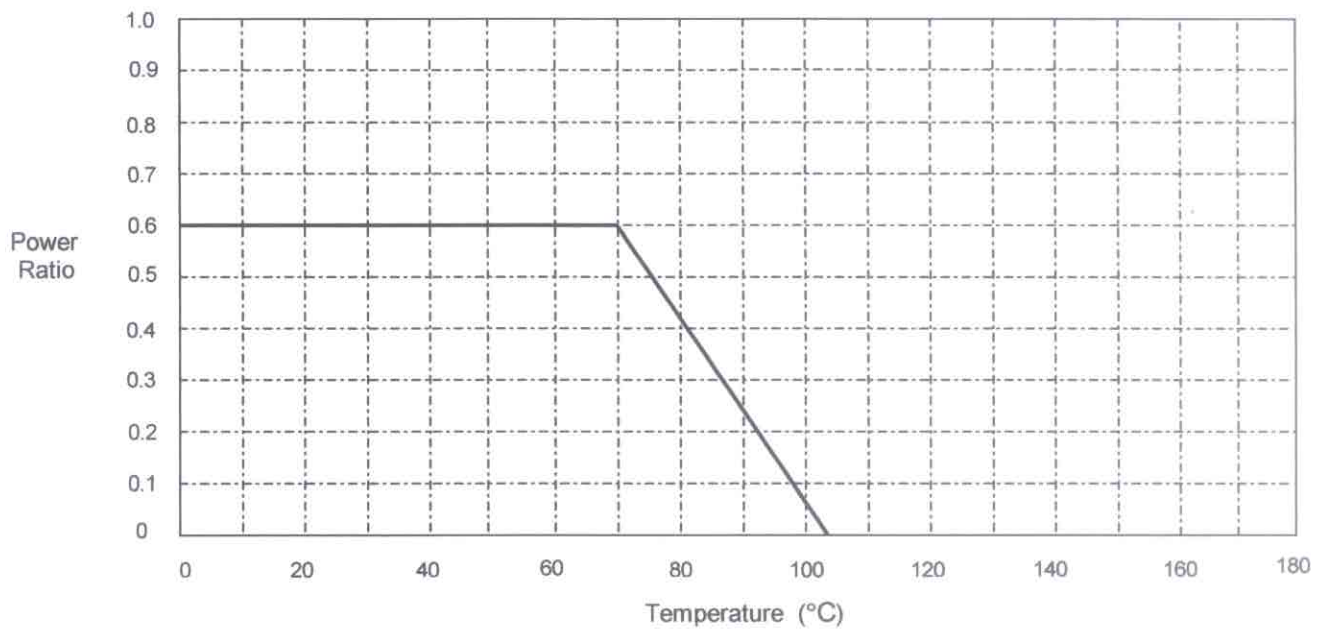
Fixed Wirewound, Power
Type RWR
MIL-PRF-39007



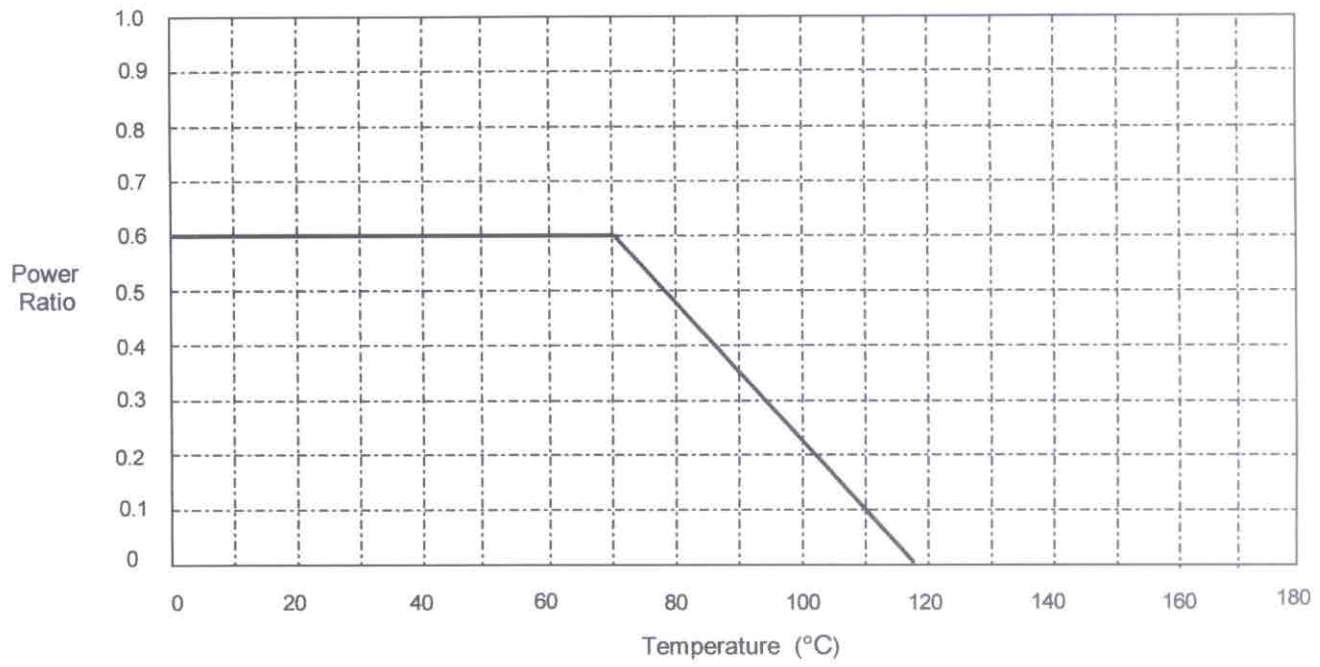
Fixed Wirewound, Power,
Chassis Mount
Type RER
MIL-PRF-39009



Fixed Film, Networks
Type RZO
MIL-PRF-83401



Fixed Film, Chip
Type RM
MIL-PRF-55342



3.13.2 Resistor Derating Examples

Resistor power dissipation over temperature is the most essential operating parameter in ensuring minimal resistance change over life.

Example 1

An RWR81 resistor rated at 3W is intended for an application where operating temperature is +70°C.

The derating graph for RWR style resistors indicates that at +70°C this resistor should be derated to 0.4 times its rated power.

For this application, resistor current must be limited to maintain power dissipation at 1.2W maximum.

Example 2

A 0.1W, metal film type RNC55 resistor is operated at +100°C. The graph for this resistor indicates that the resistor should be derated to 0.6 times rated power or 0.06W.

The resistor has a resistance value of 475KΩ and maximum voltage rating specified at 200V.

Calculating maximum allowed voltage: $200V \times 0.8 = 160V$

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

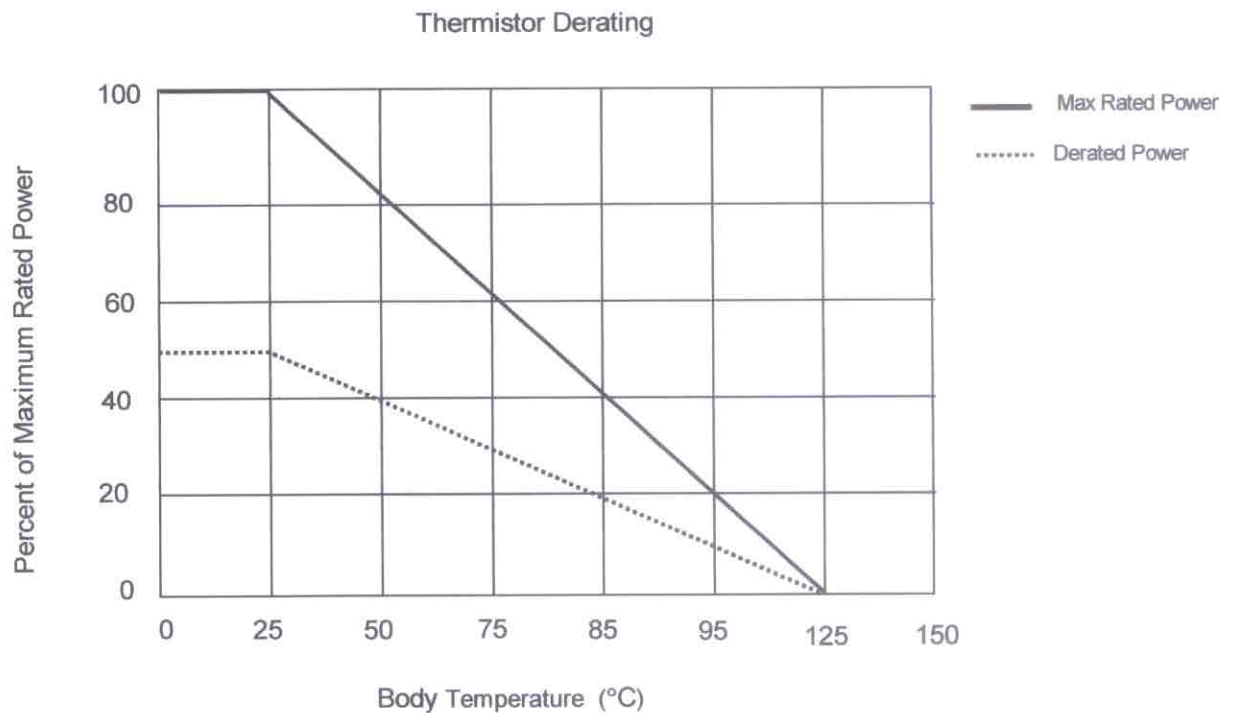
3.14 THERMISTORS

This derating criteria applies to positive and negative temperature coefficient thermistors covered by MIL-PRF-23648 (RTH series) and GSFC specification S-311-P-18 (YSI 44900 series). For derating criteria pertaining to all other thermistor styles, contact the part specialist.

Critical stress parameters for thermistors are power dissipation and operating temperature.

Derate maximum rated power as shown in the graph below.

Note that maximum rated power is defined as the maximum power the thermistor can dissipate for an extended period of time and still maintain acceptable stability of it's characteristics.



3.15 TRANSISTORS

Derating for transistors is accomplished by multiplying the critical stress parameter by the appropriate derating factor and by limiting junction and channel temperatures.

Table 3.15-1 Transistor Derating Factors

Transistor Type	Critical Stress Parameter	Derating Factor	Maximum Junction/Channel Temperature
<u>Bipolar</u> General Purpose Switching Chopper Unijunction Power <u>4/</u> <u>Field Effect</u> JFET Small Signal MOSFET	Power Current Voltage <u>1/</u>	0.50 0.75 0.75	<u>2/</u>
<u>Field Effect</u> Power MOSFET <u>3/ 4/</u>	Power Current Voltage (V_{DS}) <u>1/</u> Voltage (V_{GS}) <u>1/</u>	0.50 0.75 0.75 0.65	<u>2/</u>
<u>RF/ Microwave</u> Silicon GaAs	Power Current Voltage <u>1/</u>	0.50 0.75 0.75	<u>2/</u>

Notes:

- 1/ Voltage derating factor applies to worst-case combination of DC, AC and transient voltages.
- 2/ Maximum junction or channel temperatures for all transistor types shall be limited to 125°C or to 40°C below the manufacturer's maximum rating, whichever is lower.
- 3/ Power MOSFET devices when operated in the off-mode may be susceptible to catastrophic failure mechanisms, specifically Single Event Gate Rupture (SEGR), resulting from heavy ion impact. Parts shall be evaluated for SEGR at the lowest V_{GS} application voltage to establish a survival voltage (V_{DS}). Application drain voltage shall be derated to 75% of the established survival voltage.
- 4/ Power transistors (MOSFET and Bipolar) when biased off may be susceptible to Single Event Burnout (SEB). Test requirements for SEB are similar to those for SEGR except that drain or collector current must be measured to detect burnout and establish a survival collector voltage. Application voltage shall be derated to 75% of the survival voltage established by testing at the LET referenced in the IPPR.

3.15.1 Transistor Derating Examples

Example 1

A general purpose transistor in a TO-18 case has a maximum rated power dissipation (P_D) of 1W @ $T_C = 25^\circ\text{C}$. Maximum rated collector-emitter voltage (V_{CE}) is 50V; maximum rated collector current (I_C) is 800mA. Junction to case thermal resistance ($R_{TH(J-C)}$) is specified at 150°C/W .

Part is operating at V_{CE} of 10V, I_C of 200mA and case temperature of $+70^\circ\text{C}$. During application, maximum power dissipation is calculated at 160mW.

Applying derating criteria:

$$I_C \text{ max} = 0.75 \times 800\text{mA} = 600\text{mA}$$

$$V_{CE} \text{ max} = 0.75 \times 50\text{V} = 37.5\text{V}$$

$$P_D \text{ max} = 0.5 \times 1\text{W} = 500\text{mW}$$

Calculating junction temperature:

$$T_J = T_C + R_{TH(J-C)} \times P_D$$

$$= 70^\circ\text{C} + (150^\circ\text{C/W} \times 0.16\text{W})$$

$$= 70^\circ\text{C} + 24^\circ\text{C} = 94^\circ\text{C}$$

Example 2

A power MOSFET transistor is rated at maximum power dissipation (P_D) of 30W @ $T_C = 100^\circ\text{C}$. Maximum rated drain-source voltage (V_{DS}) is 100V; maximum rated gate-source voltage (V_{GS}) is 20V; maximum rated drain current (I_D) is 14A. Junction to ambient thermal resistance ($R_{TH(J-C)}$) is specified at 1.67°C/W .

Part is operating at V_{DS} of 60V, I_D of 6A. Maximum power dissipation is calculated at 13W at a case temperature of 85°C .

Applying derating criteria:

$$I_D \text{ max} = 0.75 \times 14\text{A} = 10.5\text{A}$$

$$V_{DS} \text{ max} = 0.75 \times 100\text{V} = 75\text{V}$$

$$P_D \text{ max} = 0.5 \times 30\text{W} = 15\text{W}$$

Calculating junction temperature:

$$T_J = (R_{TH(J-C)} \times P_D) + T_C$$

$$= (1.67^\circ\text{C/W} \times 13\text{W}) + 85^\circ\text{C}$$

$$= 21.7^\circ\text{C} + 85^\circ\text{C} = 106.7^\circ\text{C}$$

Part is in conformance with standard derating criteria but the application should be evaluated by the radiation specialist to determine if additional derating is required for the radiation environment. See notes 3/ and 4/ above.

Note that operation in space vacuum or in low atmospheric pressure conditions provides little or no convective heat transfer. For this reason, operating temperature, as applied to space environment is defined as maximum temperature of the device heat sink or other mounting surface in contact with the part or the case temperature of the part itself.

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